

RISK-BASED DECISION-MAKING GUIDELINES

Volume 2 Introduction to Risk-based Decision Making

Overview of Assessment Tools

Chapter 6 — Risk Assessment Tools

Chapter Contents

This chapter provides an overview of some of the risk assessment tools that are used for marine systems. The brief summaries are in a tabular format and point to the specific locations in Volume 3 where additional information on these tools can be found.

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Overview of Commonly Used Risk Assessment Tools

There are many hazard and risk assessment tools. The tables that follow provide a brief overview of 12 commonly used tools that are well suited to risk assessments of marine systems. They include:

1. Pareto analysis
2. Checklist analysis
3. Relative ranking/risk indexing
4. Preliminary risk analysis (PrRA)
5. Change analysis
6. What-if analysis
7. Failure modes and effects analysis (FMEA)
8. Hazard and operability (HAZOP) analysis
9. Fault tree analysis (FTA)
10. Event tree analysis (ETA)
11. Event and causal factor charting
12. Preliminary hazard analysis (PrHA)

Risk Assessment Tools

Overview of Commonly Used Risk Analysis Tools

Hazard Risk Analysis Methods	Summary of Method	More Common Uses	Location
Pareto Analysis	Pareto analysis is a ranking technique based only on past data that identifies the most important items among many. This technique uses the 80-20 rule, which states that about 80 percent of the problems are produced by about 20 percent of the causes.	<ul style="list-style-type: none"> Can be used for any type of system, process, or activity as long as enough historical data are available Usually used to find the most important risk contributors so that more detailed risk assessments can be performed later 	Volume 3, Chapter 3
Checklist Analysis	Checklist analysis is an evaluation against existing guidelines in the form of one or more checklists.	<ul style="list-style-type: none"> Useful for any type of system, process, or activity, especially when suitable checklists of accident prevention requirements or best practices exist Most often used when the use of other, more precise, methods such as FMEA and HAZOP analysis are not possible or practical Checklist analysis is frequently combined with what-if analysis to add depth and allow for creative thinking An error-like situation checklist is a special type of checklist for use in human reliability analysis A walkthrough analysis is a type of human factors checklist helpful for understanding equipment characteristics as they relate to worker actions The Root Cause Map is a special graphical checklist used in incident investigations to determine root causes 	Volume 3, Chapter 4
Relative Ranking/Risk Indexing	Relative ranking/risk indexing uses measurable features of a vessel, shore facility, port, or waterway to calculate index numbers that are useful for comparing risks of different options. These index numbers can, in some cases, be related to actual performance estimates.	<ul style="list-style-type: none"> Used to set priorities for boarding and inspecting foreign-flagged vessels Suited to any type of analysis, especially when only relative priorities are needed, as long as a proper scoring tool exists Foreign Vessel Targeting Matrix, Waterway Evaluation Tool, Ports and Waterways Safety Assessment, and Rank Risk, Target Risk and Coast Guard methodologies using the relative ranking/risk indexing technique 	Volume 3, Chapter 5
Preliminary Risk Analysis (PfRA)	PfRA is a simplified approach to accident-based risk assessment. The main goal of the technique is to define the risk related to important accident scenarios. This team-based approach relies on subject matter experts examining the issues. The team suggests possible accidents, most important contributors to accidents, and protective features. The analysis also identifies the risk of the accidents and identifies recommendations for reducing risk.	<ul style="list-style-type: none"> Used for producing risk profiles across a range of activities, such as in port-wide risk assessment Coarse risk analysis is a special type of PfRA and is deviation-based instead of accident-based 	Volume 3, Chapter 6
Change Analysis	Change analysis looks logically for possible risk effects and proper risk management strategies in changing situations (e.g., when system layouts are changed, when operating practices or policies change, when new or different activities will be performed).	<ul style="list-style-type: none"> Used for any situation in which change from normal setup, operations, or activities is likely to affect risks (e.g., marine events in ports or waterways) Can be used as an effective root cause analysis method, as well as a forecasting risk assessment method 	Volume 3, Chapter 7

Overview of Commonly Used Risk Analysis Tools (continued)

Hazard Risk Analysis Methods	Summary of Method	More Common Uses	Location
What-if Analysis	What-if analysis is a problem-solving approach that uses loosely structured questioning to (1) suggest upsets that may result in accidents or system performance problems and (2) make sure the proper safeguards against those problems are in place.	<ul style="list-style-type: none"> Useful for any type of system, process, or activity Most often used when the use of other, more precise, methods (e.g., FMEA and HAZOP analysis) are not possible or practical What-if analysis is frequently combined with checklist analysis to add structure to the analysis 	Volume 3, Chapter 8
Failure Modes and Effects Analysis (FMEA)	FMEA is a reasoning approach best suited to reviews of mechanical and electrical hardware systems. The FMEA technique (1) considers how the failure modes of each system component can result in system performance problems and (2) makes sure the proper safeguards are in place. A quantitative version of FMEA is known as failure modes, effects, and criticality analysis (FMECA).	<ul style="list-style-type: none"> Used for reviews of mechanical and electrical systems (e.g., fire suppression systems, vessel steering and propulsion systems) Often used to make planned maintenance and equipment inspection plans more effective Sometimes used to gather information to help find trouble areas in systems 	Volume 3, Chapter 9
Hazard and Operability Analysis (HAZOP)	The HAZOP analysis technique uses special guide words for (1) suggesting departures from design intents for sections of systems and (2) making sure that the proper safeguards are in place to help prevent system performance problems.	<ul style="list-style-type: none"> Used for finding safety hazards and operability problems in continuous process systems, especially fluid and thermal systems. Also used to review procedures and other sequential or batch operations Another type of guide word analysis technique is Worker and Instruction Safety Evaluation, which is used to understand the significance of human errors 	Volume 3, Chapter 10
Fault Tree Analysis (FTA)	FTA is a technique that graphically models how logical relationships between equipment failures, human errors, and external events can combine to cause specific accidents of interest. Probabilities and frequencies can be added to the analysis to estimate risks numerically.	<ul style="list-style-type: none"> Suited to almost every type of risk assessment, but best used to focus on the basic causes of specific system failures of relatively complex combinations of events Often used for complex electronic, control, or communication systems 5 Whys is a less complicated fault tree analysis technique used in incident investigations to determine root causes 	Volume 3, Chapter 11
Event Tree Analysis (ETA)	ETA is an analysis technique that uses decision trees to model the possible outcomes of an event that can produce an accident of interest. Probabilities and frequencies can be added to the analysis to estimate risks numerically.	<ul style="list-style-type: none"> Suited to almost every type of risk assessment, but best used to focus on possible results of events for which many safeguards are in place as protective features Often used for analysis of vessel movement incidents, the spread of fires or explosions, or toxic releases A human reliability analysis event tree is a specific and detailed method used in modeling human reliability 	Volume 3, Chapter 12

Risk Assessment Tools

Overview of Commonly Used Risk Analysis Tools (continued)

Hazard Risk Analysis Methods	Summary of Method	More Common Uses	Location
Event and Causal Factor Charting	Event and causal factor charting is used to understand how an accident occurred, by finding specific equipment failures, human errors, and external events contributing to the accident. Then, the analysis continues to discover the underlying root causes of the key contributors to the accident and to make recommendations for fixing the root causes.	<ul style="list-style-type: none"> Used to study any accident or some selected problem Event and causal factor charting is most commonly used when the accident scenario is complicated, involving a chain of events or a number of root causes 	Volume 3, Chapter 13
Preliminary Hazard Analysis (PHA)	The PHA technique is a broad, basic study that focuses on (1) finding hazards, (2) assessing the severity of accidents that could occur involving the hazards, and (3) finding protective features or safeguards for reducing the risks of the hazards. This technique focuses on finding weaknesses early in the life of a system, thus saving time and money that might be needed for major redesign if the hazards are found later.	<ul style="list-style-type: none"> Usually conducted early in the development of an activity or system when there is little detailed information or few operating procedures, and is often the first of further risk assessments In any type of system or process, used to identify and rank hazards 	Volume 3, Chapter 14

Summary of Key Features

Risk Analysis Method	Types of Results				Level of Effort/Complexity	Level of Expertise Required for Analysis Teams
	Qualitative Accident Descriptions	Quantitative Risk Characterizations	Relative Importances of Accident Contributors	Recommendations		
Pareto Analysis	✓	✓	✓	✓	All	Low to medium
Checklist Analysis				✓	All	Low to medium
Relative Ranking/Risk Indexing	✓	✓	✓	✓	All	Low to medium
PrRA	✓	✓	✓	✓	All	Medium
Change Analysis	✓	✓	✓	✓	All, but generally for systems experiencing recent changes in design or operation	Low to medium
What-if Analysis	✓			✓	All	Low to medium
FMEA	✓	✓	✓	✓	All, especially mechanical and electrical systems	Medium to high
HAZOP Analysis	✓			✓	Cargo loading and unloading systems, especially fluid and thermal systems Sequential operations and procedures	Medium

Risk Assessment Tools

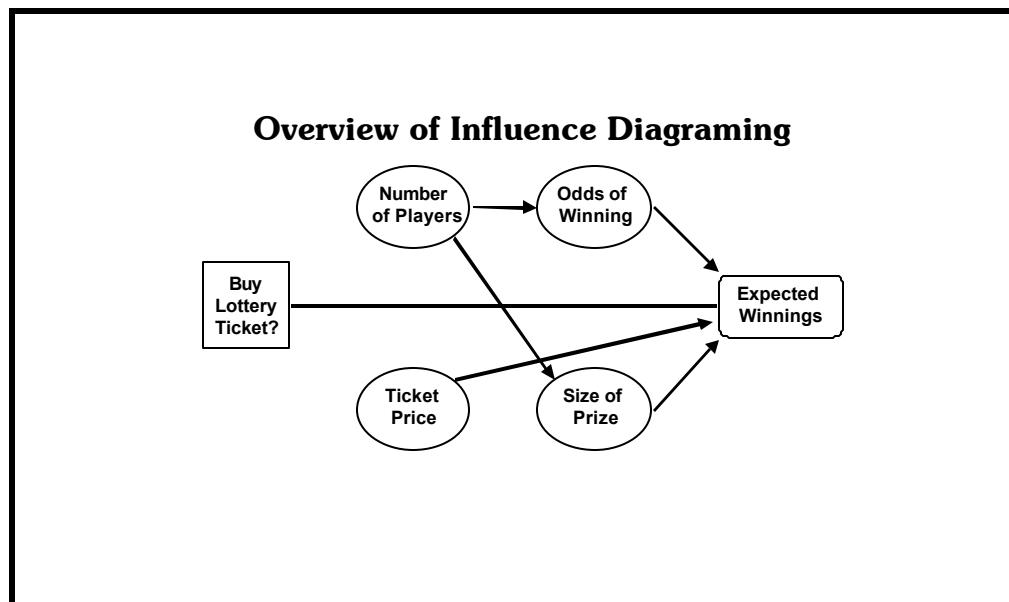
Summary of Key Features (continued)

Risk Analysis Method	Types of Results			Level of Effort/Complexity	Level of Expertise Required for Analysis Teams
	Qualitative Accident Descriptions	Quantitative Risk Characterizations	Relative Importances of Accident Contributors		
FTA	✓	✓	✓	✓	Medium to high
ETA	✓	✓	✓	✓	High
Event and Causal Factor Charting	✓			✓	Medium to high
PrHA	✓	✓		✓	Low to medium
				All	High
				All	Low to medium
				All	Low to medium

Overview of Operational Risk Management

Overview of Operational Risk Management

Operational Risk Management (ORM) is another risk assessment tool used in the Coast Guard and referred to in these *Guidelines*. The ORM policies are described in COMDTINST 3500.3. ORM focuses primarily on safety and health issues, looking at Coast Guard internal risks to personnel and property arising from unit operations. It features simple models, tools, and checklists that concentrate primarily on tactical situations related to Coast Guard activities. Although internally focused, the ORM tools have some limited applicability to marine safety decisions, especially those related to preparedness and response issues. Often, the complexity of marine safety issues and the number of associated stakeholders prevent the application of ORM, but you should consider whether ORM will yield suitable information and support for the risk-based decision.



Overview of Influence Diagramming

An influence diagram is a powerful tool for identifying hazards, evaluating risk, determining risk management options, and communicating hazards. By providing a framework for the decision, influence diagrams link the real world with the analytical model. An example influence diagram is shown in the figure above.

As can be seen, influence diagrams are constructed of three elements: branches, directed arcs, and nodes. Nodes are used to capture the various stages for the problem. There are three types of nodes:

- Decision nodes (e.g., buy lottery ticket?)
- Event nodes (e.g., odds of winning)
- Value nodes representing the results of a decision process (e.g., expected winnings)

The nodes are drawn as squares, ovals, and rounded rectangles, respectively. They are typically arranged from left to right, to match the flow of time.

Branches can be used in two ways. They can show possible outcomes of random events, and they can describe possible alternatives. Branches are drawn as line segments between nodes.

Directed arcs are used to show possible conditional dependence. They are drawn as arrows connecting nodes, with the direction indicating dependence. In the example above, they are used to show the effects of the various quantities (e.g., number of players) on later quantities (e.g., odds of winning).

Though this overview is qualitative, influence diagrams can be used quantitatively by applying probabilities to model future events based on the influence of previous events.